Oct. 11, 1932. J. SEDLMAYER 1,882,653

SIGNAL TRANSMISSION SYSTEM

Filed Nov. 10, 1931

FIG. 1

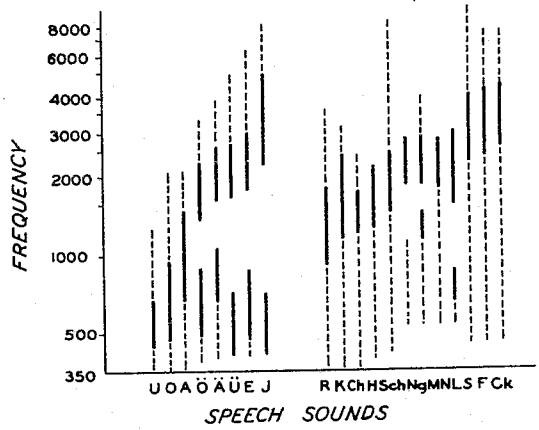


FIG. 2

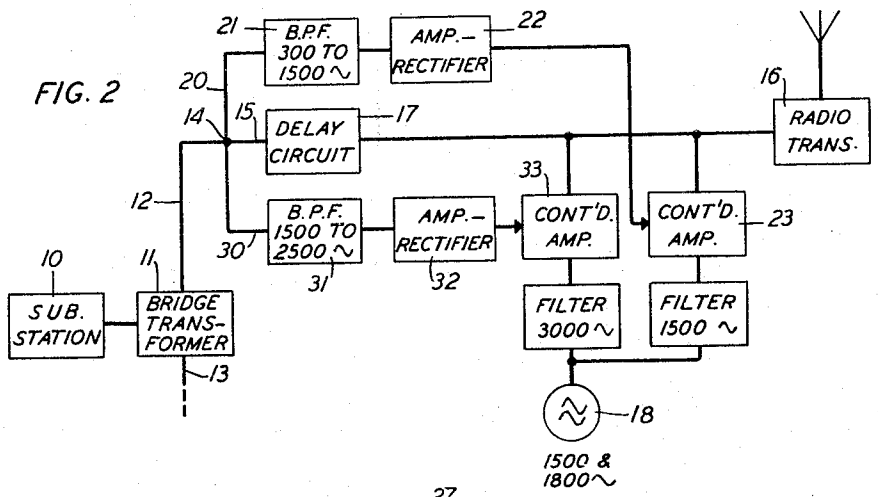
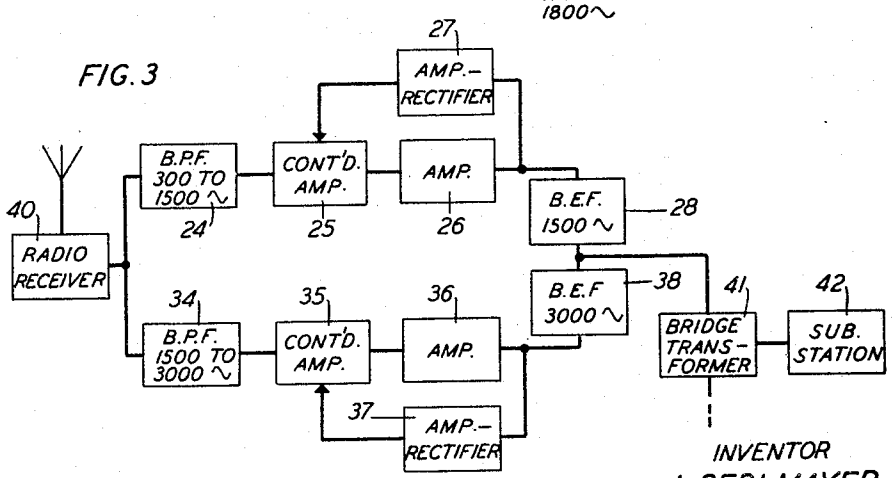


FIG. 3



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SIGNAL TRANSMISSION SYSTEM

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Application for this invention filed in Germany November 6, 1930.

This invention relates to signal transmission systems and particularly to short wave radio telephone systems.

An object of the present invention is to reduce the effects of fading phenomena, such as particularly occur in short wave radio transmission.

One general type of method which has been used for the control of such phenomena is by automatically controlling the gain of the receiver. Certain methods of automatic gain control previously proposed for this purpose depend upon the uniform regulation of the whole signal band, i. e., the same degree of control is applied to all the frequencies. A disadvantage of these methods is that they do not correct for selective fading phenomena which cause variations in the relative transmission of various frequencies in the signal band.

In accordance with a feature of the present invention these disadvantages are reduced by the fact that the frequency range to be controlled is sub-divided and each of the component bands is controlled per se. Moreover, in order to obtain a particularly good control, both the transmitted signals and pilot tones are employed to effect the control.

The causes of selective fading phenomena may be of various kinds. Insofar as it is a question of interference phenomena, these may be eliminated within certain limits by making the transmission paths as clear as possible. In accordance with the present invention fading phenomena, irrespective of their causes, may be rendered harmless by selective control. Theoretically, the best control is obtained by dividing the frequency band to be transmitted into sub-bands, each as narrow as possible and providing each of the sub-bands with its own control. However, such an extensive sub-division need not be made in practice, for by dividing the signal into a small number of component bands, even two, considerable improvement is obtained. The sub-division should preferably be performed in such a way that each of the component bands includes a substantial portion of the signal energy.

There are three possibilities of effecting the control either in the case where component bands are used or in the case where the signal band is not sub-divided. It has been proposed to allot to the frequency band to be controlled a simultaneously transmitted pilot tone or control frequency which is used to control the degree of amplification or gain of the receiver. Another method is to employ the transmitted signal currents themselves for the control of the receiver.

There are disadvantages in both methods, however. The first method has the disadvantage that the signal frequencies are controlled according to the attenuation of the control frequency and not according to their own attenuation. Thus, when the control frequency and signal frequencies undergo fading of different intensity (selective fading), this method of control will result in such an adjustment of the amplitude of the signal as to correct for the fading of the control frequency and may result in an increased distortion rather than a correction.

The second method is applicable very well to all the cases in which the signals are of constant amplitude, without pauses in transmission. On the other hand it is inefficient in speech transmission, for the reason that the fluctuations of amplitude of the signal are considerable and must not be leveled. In order to prevent such a leveling as would distort the character of the speech, there must be employed controlling devices of large time constants. These control circuits, consequently, cannot follow rapid fadings. This method has a further disadvantage that in the speech pauses the atmospheric disturbances are raised to speech intensity. Moreover, since in this method of control the transmission of the speech path is dependent upon the speech amplitude, the variations therein cause a tendency to howl. (See E. N. T. 1928, volume 11, H. F. Mayer "Über automatische amplitudenbegrenzer").

In accordance with the present invention the advantages of both methods are combined and their disadvantages eliminated.

This is accomplished by effecting the gain control in accordance with both the signal currents themselves and a special control current having at the transmitter such an amplitude that when rectified along with the signal currents there results a rectified current of a constant value. In the receiving apparatus the degree of amplification or gain is controlled in response to the current resulting from the rectified received signals and control current. After the control current is filtered out of the resulting wave, there remains only the signal currents. Preferably, the average amplitude of the control frequency is chosen small with respect to the signal frequency amplitudes, so that the amplitude of the controlled wave is primarily dependent upon the latter. During the signal pauses the control frequency alone is present, so that the degree of amplification of the repeater is adjusted to a moderate level and interference noises are not introduced.

If several control tones are required, then it is preferable to choose their frequencies according to integral or approximately integral proportions, in order to avoid the formation of combination tones within the voice band. Thus, for example, a fundamental tone and overtones or the overtones alone are employed. These may be produced by generators or oscillators of well known type.

The frequencies of the control tones are preferably so chosen that they are located on the edges of the frequency bands to be regulated. They can then be very easily filtered out without signal frequencies being suppressed with them. In the case where the signal band is divided into two component bands it is advantageous to select the frequency of the control tone so that it is located in the middle of the total band, i. e., between the two component bands, since in this way the limits of the component bands may be so chosen that harmonics of the lower control frequency come outside the signal band. This latter fact, that is, that the overtones of the control frequencies fall outside the voice band, is advantageous in every case. In the arrangement of the control frequency in the middle of the total band, the only disadvantage is that the signal frequencies in the immediate vicinity of the control frequencies may also be filtered out simultaneously therewith. With filters of sufficiently small band width, however, the harmful influence to intelligibility is rendered so small that it is outweighed by the advantages.

This method of employing signal currents and control currents jointly for the gain control, may not only be employed for the case of sub-division of the signal band as described herein, but also in the case where the band to be controlled is not sub-divided.

The invention may be more readily understood by reference to the following detailed description in connection with the drawing in which:

Fig. 1 is a graph showing a survey of the frequency distribution of human speech; and

Figs. 2 and 3 show diagrammatically a radio telephone system embodying the invention, Fig. 2 showing the transmitter and Fig. 3, the receiver.

Fig. 1 shows a survey of the frequencies contained in various sounds of human speech. The full lines indicate which frequencies are primarily contained in the sound concerned. The frequencies over which the dotted lines extend are also contained to a small extent in the sounds concerned, but without being of importance for the specific character. By means of such a diagram the considerations which are decisive for the frequency subdivision may be ascertained. The intelligibility losses following therefrom are decisive for the number and position of the component portions. In most cases it will be of advantage to make a sub-division in two ranges so that each embraces a main forming range.

Figs. 2 and 3 show diagrammatically a radio telephone system embodying the invention. The elements of the system are all circuits of well known types and consequently are shown only in block diagram form.

Let us first refer to Fig. 2 which shows the transmitter. A telephone subset 10 including a telephone transmitter is connected through a bridge transformer 11 to the lines 12 and 13 leading respectively to the radio transmitter and to a radio receiver (not shown). The audio frequency currents pass from the transmitter of the subset 10 through the transformer 11 and line 12 to the junction point 14 where the path is divided into three branches 15, 20 and 30. Branch 15 is the transmission path. The two branch lines 20 and 30 provide for the control of the pilot currents. The voice band is divided into component or sub-bands in these paths 20 and 30 and separate control or pilot tones supplied for each sub-band.

Branch 20 contains a band-pass filter 21, which for example, passes frequencies of 300–1500 cycles. The output of this filter is supplied to an amplifier-rectifier 22 of the well known type. Similarly, branch 30 contains a band-pass filter 31 having a range of free transmission of 1500–2500 cycles and an amplifier-rectifier 32.

The transmission path 15 itself transmits the whole voice frequency range (300–2500 cycles) so that the signal currents are transmitted to the radio transmitter proper 16 over this path, which contains only a delay circuit 17. This circuit is designed to compensate for the phase shift in the control paths 20 and 30 so that the pilot tones introduced will bear the proper phase or time relation to the signal currents.

The partial frequency bands flowing through the control paths effect the adjustment of the control currents (pilot tones) by means of the amplitude controllers 23 and 33. These control currents are generated in an oscillator 18 which is of the harmonic generation type producing harmonic waves of 1500 and 3000 cycles. The filters or tuned circuits 33 and 23 are designed to select the respective pilot tones of 3000 and 1500 cycles. The filter 33 may have cut-off frequencies of 2700 and 3300 cycles and selects the 3000 cycle tone which is allotted to the frequency band of 1500–2500 cycles. Similarly, the filter 20 may be a low pass filter having a cut-off frequency of 1800 cycles and operates to select the 1500 cycle tone which is allotted to the 300–1500 cycle sub-band.

The 1500 and 3000 cycle pilot tones are supplied to the amplitude control circuits 23 and 33 respectively. These circuits are similar in action and are designed in accordance with the well known principles of operation of gain control amplifiers. For example, circuit 23 operates to control the amplitude of the 1500 cycle pilot tone in accordance with the amplitude of the rectified current output of the amplifier-rectifier 22 which represents at any instant the average amplitude of the voice currents in the 300–1500 cycle sub-band. The circuit is designed to effect such a control that when the resulting 1500 cycle pilot tone is rectified along with the 300–1500 cycle sub-band the resultant rectified current will be constant in amplitude.

The amplitude control circuit 33 is similarly responsive to the 1500–2500 cycle sub-band to produce such a control of the 3000 cycle pilot tone that when it is rectified along with the 1500–3000 cycle sub-band there results a constant current.

The control tones regulated in this manner by the component frequency bands allotted thereto are retransmitted together with the signal currents to the radio transmitter 16 where they modulate the carrier wave and are radiated from the antenna.

As described above the delay circuit 17 performs the function of equalizing the time of transmission in the transmission path 15 with that of the two control paths 20 and 30 so that there will be a proper phase relation between the signal currents and the introduced pilot tones.

Fig. 3 shows the receiving system. The radio waves received in the antenna are amplified and detected in the radio receiver 40. The resultant signal and pilot currents leaving the receiver 40 are divided by means of the band-pass filters 24 and 34 into two frequency bands. The filter 24 has a pass-range of 300–1500 cycles and the filter 34, a pass-range of 1500–3000 cycles. The currents of these two frequency bands are then controllably amplified in the controlled amplifiers 25 and 35, and transmitted through the unilateral transmission circuits 26 and 36, which by preventing back couplings increase the stability of the control circuits. The outputs of the circuits 26 and 36 are each divided into two paths, one leading to the inputs to the respective amplifier-rectifiers 27 and 37. The currents are rectified therein and supplied to the control amplifiers 25 and 35 respectively operating to so control the gain thereof as to compensate for the effects of fading.

The other paths lead to the band elimination filters 28 and 38 which are designed to filter out the 1500 and 3000 cycle control tones, respectively. These filters are designed to be sharply selective to the control tones and to pass all of the signal frequencies. The remaining signal currents are then recombined and transmitted through a bridge transformer 41 to the subset 42 which includes a telephone receiver.

The control amplifiers 25 and 35 are designed in accordance with the well known principles of operation of gain control amplifiers so that they operate to always maintain the output of the respective amplifier-rectifiers 27 and 37 constant in amplitude.

The arrangement according to this invention may be combined with known devices for secrecy of the sub-divided signal band type. In this way certain of the circuit elements may be used to perform two functions. Preferably, particularly in the transmission of speech, the combination is made with a secrecy system in which the signal band is not only sub-divided but the sub-bands are also displaced in the frequency spectrum. The filtering means necessary for the sub-division may be so dimensioned that they can also be employed for the control arrangement so that thus a substantial reduction of circuit elements and consequently of cost results

In order to reduce the disturbing influence of non-linear distortions, such as may be produced by selective fading phenomena, it is advisable to transform the signal frequencies for the transmission to a frequency range for which the differential tones are below and the overtones above the band. The relative position of the control frequencies to the voice frequencies can be maintained. Thus, for example, instead of the band 300–3000 cycles, the band 4000–6700 cycles may be employed. This band is obtained by heterodyning with 3700 and 7000 cycle waves, respectively. It will be seen that the highest differential tone (2700 cycles) is below this band and the lowest overtone (8000 cycles) above this band. At the receiving station the shifted band is restored to its proper place in the frequency spectrum in a corresponding manner. Amplitude control and complete or substantial filtering out of the control frequencies are preferably per-

formed in the shifted frequency band, i. e., before the reconversion.

Also, in cases in which there is no such frequency transformation at the transmitting station, it is advisable at the receiving station to first shift the signal frequency to a suitable place in the frequency spectrum, by means of heterodyne reception. The control amplifiers and pilot tone filters are then operated in this frequency range and after control and filtering the resultant band is shifted back to its original position in the frequency spectrum.

The improvements obtained by the arrangement according to this modification may be so considerable that thereby the use of suppressors is rendered unnecessary. For this reason the extra cost is not material, particularly when the improvement in intelligibility is taken into consideration. Moreover, it is possible to employ one or both control frequencies for telegraphy.

What is claimed is:

1. In a radio signaling system, the method of reducing the effects of fading which comprises allotting to each of a plurality of portions of the signal band a control tone of signal frequency located substantially at a limit of the corresponding portion of the signal band and having an amplitude which bears a definite relation to the amplitude of the waves in the respective portions of the signal band, separating the received waves into sub-bands, each corresponding to one of said portions of the signal band, separately amplifying each sub-band and controlling the amplification of each sub-band in accordance with both the amplitude of the respective control tone and the amplitude of the current in said sub-band.

2. In a radio signaling system, the method of reducing the effects of fading which comprises allotting to each of a plurality of portions of the signal band a control tone the amplitude of which bears a definite relation to the amplitude of the waves in the respective portions of the signal band, said control tone being harmonically related, separating the received waves into sub-bands corresponding to one of said portions of the signal band, separately amplifying the sub-bands, and controlling the amplification of each sub-band in accordance with both the amplitude of the respective control tone and the amplitude of the current in said sub-bands.

In witness whereof, I hereunto subscribe my name this 8th day of October, 1931.

JOSEF SEDLMAYER.